EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 71, 2305:2315, July, 2025

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 19-03-2025 • Accept Date : 20-05-2025 • Available online: 10-07-2025 • DOI : 10.21608/edj.2025.369550.3423

DIGITAL VERSUS DIRECT INCORPORATION OF BALL ATTACHMENTS TO MANDIBULAR IMPLANT OVERDENTURE: EFFECT ON PERI-IMPLANT TISSUE HEALTH AND ALVEOLAR BONE HEIGHT.

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ABSTRACT

Purpose: This clinical trial aimed to compare the effect of direct functional pick-up versus digital indirect pick-up techniques for implant overdenture attachments on peri-implant soft tissue health and alveolar bone height.

Methods: Thirty completely edentulous patients were selected in this study, each patient received two mandibular implants in the canine regions. Ball and socket attachments were screwed to implants after osseointegration. According to technique of construction of definitive complete overdenture and pick-up all cases were randomly divided into two groups: conventional group (n = 15): obtained conventional denture base with direct pickup technique and 3D-milled group (n = 15): obtained CAD/CAM milled denture base with digital (indirect) pickup technique. Peri-implant bone loss and probing depth were measured at time of overdenture insertion (T0), 6 months (T6) and 12 months after insertion (T12).

Results: There was insignificant difference between the two groups at T0-T6 (P=0.843), T6-T12 (P=0.856), and T0-T12 (P=0.916) Regarding peri-implant alveolar bone loss, However, significant differences were observed in both groups with advance of time (T0-T6, T6-T12) (P<0.001). Regarding Peri-implant probing depth, there was insignificant difference between groups at T0 (P=0.615), T6 (P=0.426), and T12 (P=0.881), However significant differences occurred with advance of time in both groups (T0-T6, T6-T12) (P<0.001).

Conclusion: The digital indirect pick-up technique for implant overdenture attachment in milled denture bases can be regarded as a precise approach comparable to direct functional pick-up in conventional denture regarding peri-implant bone loss and probing depth.

KEYWORDS: CAD/CAM milled denture base, digital pickup, direct pick up, implant overdenture.

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INTRODUCTION

Insertion of dental implants in completely edentulous individuals gives stability and support for complete dentures, therefore providing a more practical and aesthetically acceptable alternative for traditional complete dentures. McGill and York stated that minimum two implants is the standard required for preserving overdentures, thereby assuring suitable retention and stability, enhanced oral health-related quality of life (OHRQL), cost-effectiveness, and higher patient satisfaction. [(1)]

The attachment design employed for an overdenture improves retention and stability. One might classify attachment systems as either splinted attachments or isolated attachments. Isolated attachment is designed to link on their own to every implant. While splinted attachments consist of a bar linking the implant, Ball and Socket attachments, magnetic attachments, and locator attachments are the most widely utilized attachment methods. [(2)]

There are many techniques to include attachments within the overdenture. They might be classified as direct procedures (done intraorally in a clinical environment) or indirect methods (done extraorally in a dental laboratory). [(3)] Extraoral integration of metal housings into their respective cavities inside the milled overdenture base is possible. The technique of attachment incorporation depends mainly on the time of attachment incorporation either in jaw relation stage or after denture processing and type of impression whether tissue level, implant level or abutment level impression. [(4)]

Historically, denture bases have come from hand processing using heat-polymerized acrylic—often producing inconsistencies and restrictions. Thanks to accurate production of denture bases made possible by CAD/CAM technology, this method has been revolutionized and various advantages for implant overdentures result. Computer-assisted design and computer-aided manufacturing Milled denture bases start with first building a digital model of the patient's oral anatomy including soft tissues and implant placements using sophisticated digital design tools. [(5)] The virtual model is then sent to a milling machine, which creates the denture foundation from a solid block of biocompatible material. This procedure produces a structurally homogeneous denture foundation with physical characteristics that strengthens its resilience to wear and fractures and increases its lifetime for extended use. [(6)]

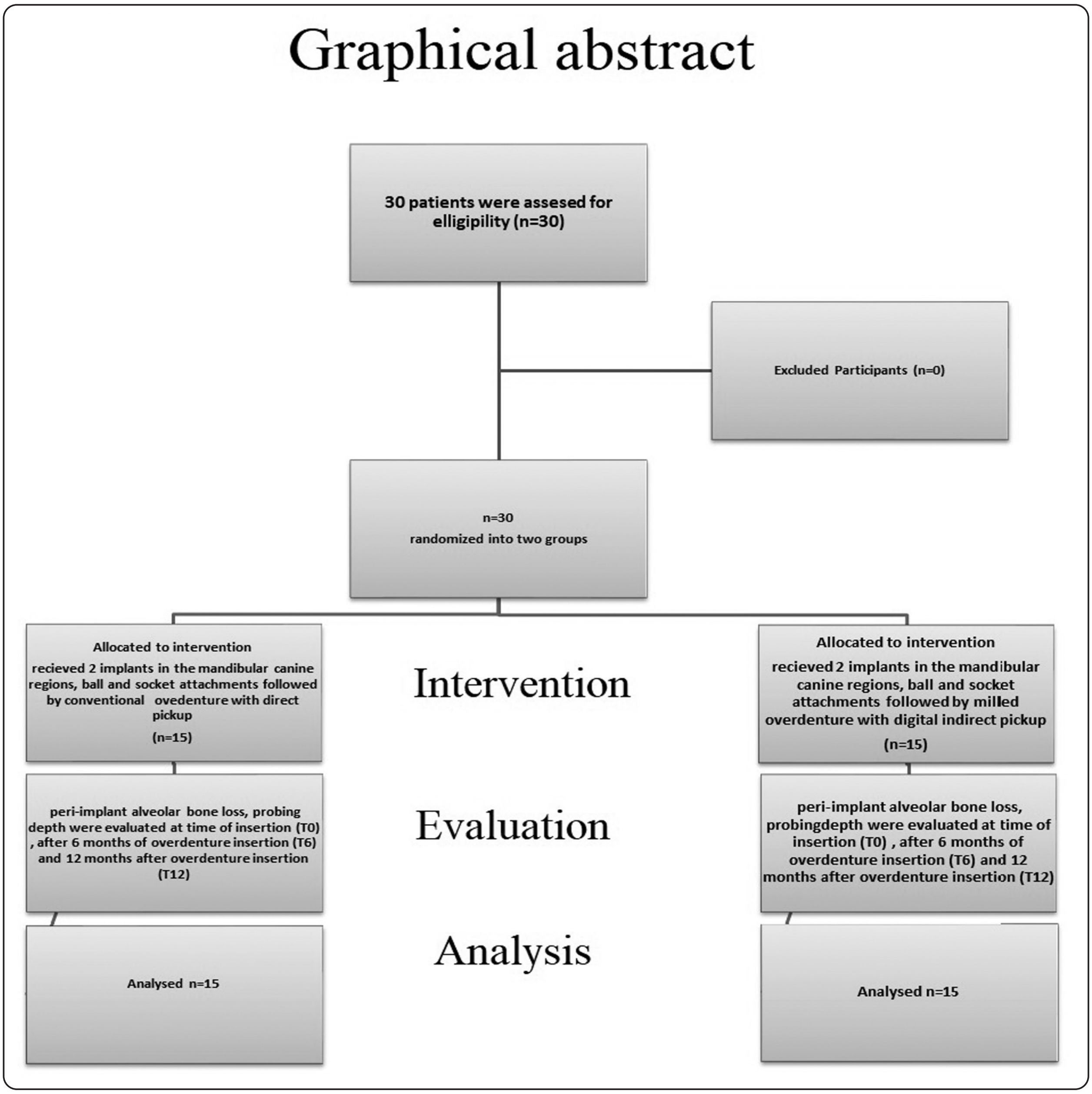
Furthermore enabling the exact integration of important design elements like undercuts, tissue relief zones, and implant attachments spaces straight into the digital framework of CAD/CAM milled denture bases. This degree of adaptation maximizes the usefulness and aesthetic appeal of the final prosthesis, hence improving general performance. [(5, 7)]

This research aims to assess the impact of two metal housing inclusion techniques: intraoral (direct pickup with a traditional overdenture base) and extraoral (indirect utilizing a CAD/CAM milled overdenture base) on peri-implant bone height and soft tissue alterations. The null hypothesis of the research posits that there is no significant difference between the two groups for alveolar bone loss and probing depth.

MATERIAL AND METHODS

Study design

Thirty completely edentulous patients with recently osseointegrated implants in the mandibular canine regions were selected From the prosthetic department at the Faculty of Dentistry, Mansoura University, For this study, the patients received thorough education on the goal of prosthodontic treatments and signed their formal consent. The Ethical Committee of Mansoura University Dental Research approved the study (No. M030410). Based on the specified parameters, the two canine implants were vertically positioned and are parallel to one another, as confirmed by panoramic x-ray.



Good general health without systemic disorders, confirmed through a clinical evaluation carried out by a physician. Moderately developed ridge characterized by a U-shaped palatal vault and sufficient firmly attached mucosa, as assessed through visual inspection and probing tests to minimize recession and marginal bone loss post-implant placement, Class I maxillomandibular relation.

Based on results of earlier clinical studies with an effect size of 1.1, $\alpha = 0.05$, and $\beta = 0.90$, the sample size was determined. The decided upon sample size was thirty. Software ("G*power 3.1.5, Heinrich-Heine-Unversität Düsseldorf, Germany") was used for the power analysis. Patients were randomly allocated to one of two groups using a balanced randomization method. This was done to guarantee that there was a comparable level of peri-implant probing depth and marginal bone loss between the two groups, as measured by digital periapical radiographs.

For all patients, the following procedures were done

Preliminary impressions were made to maxillary and mandibular arches using irreversible hydrocolloid material (alginate impression material, Cavex) using stock trays. Primary casts were obtained from pouring preliminary impressions and custom trays were fabricated from auto-polymerizing acrylic resin (Pekatray, Bayer. Dental, Lever Kusen). The fit of the custom trays were verified intra-orally and corrections were made when necessary.

For maxillary arch:

With a green stick low-fusing compound ("Hiflex Thermoplastic green sticks, Prevest Denpro"), border molding was done. Zinc oxide impression substance ("Zinc Oxide Eugenol, Cavex, Holland Bv") yielded the clear impressions. The master cast was poured and record block was made. Using a facebow record ("Type AFB, Denatus facebow"), the maxillary record block was positioned intraorally and the maxillary cast was fastened to a semi-adjustable articulator ("ARH type, Denatus articulator").

For mandibular arch:

According to the technique of overdenture base construction and method of incorporation the metal housings of attachments all patients were randomly classified into two equal groups as follow:

Group A: patients received Conventional complete overdenture with direct pickup (intraoral) of female house at insertion.

Group B: patients received milled complete overdenture base with digital (extraoral) pick up of female house at insertion.

For conventional group (A) the following procedures were done:

Construction of mandibular overdenture:

Border molding was done for the mandibular arch using green stick low fusing Compound ("Hiflex Thermoplastic green sticks, Prevest Denpro"). The final impressions were made by using Zinc oxide eugenol free impression substance ("Zinc Oxide Eugenol, Cavex, Holland Bv"). the master cast was poured. Together with the maxillary denture, the mandibular overdenture was made from a record base created on the mandibular cast using self-curing acrylic resin. Then the acrylic base was topped with an occlusal wax rim. Using a centric inter-occlusal record, the mandibular cast was aligned with the mounted maxillary cast. The horizontal condylar angle of the semi-adjustable articulator was changed by means of a protrusive record; the lateral condylar angle was computed using Hanau equation: "$L = H/8 + 12$". artificial modified semi-anatomic teeth were Set up to attain balanced lingualized occlusion, The waxing-up process was finished, tried intra-orally. The waxed dentures were processed following along curing cycle before finishing and polishing. Laboratory remount was performed, then intraoral occlusal correction.

Direct (intra oral) pick up for group(A):

Implants cover screw were removed and healing abutment were screwed for ten days. After ten days a hex driver was used to remove the healing caps and confirm that the implant platforms are clean and free of debris. Ball abutments (3.5mm diameter and 2mm height) were screwed onto each implant (Figure 1). An indelible pencil was used to mark the top of

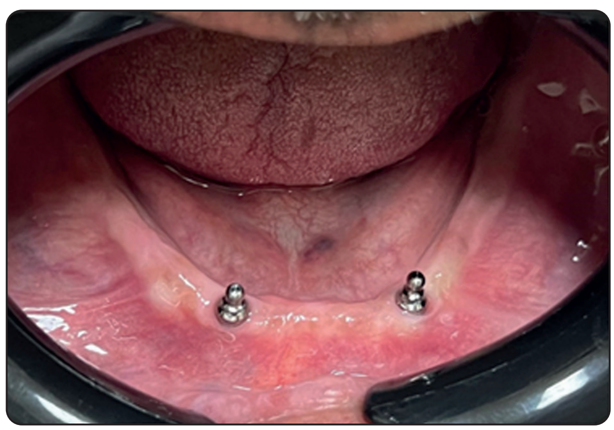


Fig. (1) Ball attachments screwed to implants in the mandibular canine regions each ball abutment then the denture was seated to determine the ideal location for the housing. Holes were created in the denture base to accommodate the female housing, lingual skip ways were made to allow skip of excess material. The nylon lab insert was inserted into the housing and the housing was placed onto each attachment (Figure 2A). Self-cure acrylic was mixed and placed in overdenture and the denture was placed intra-orally then the patient was asked to bite in centric relation. Acrylic resin was allowed to cure and the overdenture was removed (Figure 2B). The nylon lab inserts were replaced by retentive inserts, the mandibular denture was then checked for proper retention. Any necessary occlusal adjustments to the overdenture were made to ensure a comfortable fit and proper function, then the denture was delivered.

For milled group (B) the following procedures were done as follow:

Crestal incision was done to remove cover screw of implants for each patient and healing abutment were screwed for ten days, then the final impression was done as follow:

Two apertures were created in the anterior section of the mandibular custom tray around the healing abutments (“Neobiotech Company, Seoul, Korea”). Border molding was performed with a low-fusing modeling plastic impression compound. The definitive imprint of the remaining ridge was obtained using zinc oxide paste. The tray was removed, and any surplus material extending into the abutment area was eliminated.

Healing abutments were unscrewed and implant level direct transfer copings (“Neobiotech implants, Neobiotech Company, Seoul, Korea”) were screwed to implants. The elastomeric impression material (“Ghenesyl addition curing silicone impression material, LASCOD Spa, Italy”) was injected around transfer coping. The tray with zinc oxide impression was placed again until fully seated and the impression of the abutments was made. After complete setting of the impression, Duralay resin was used to splint transfer coping together and to the custom tray then transfer copings were unscrewed. The impression was removed then implant analogues were screwed to the transfer copings. Gingival mask was injected around implant analogue. The impression was then poured to produce the master cast with implant analogue. Ball attachments (“Neobiotech Company, Seoul, Korea”) were screwed into the implant analogues and their metal housing was fitted on it.

The mandibular master cast—with metal housings on ball attachment—was scanned using a 3D scanner (“Dof.SWING, CE FC, Korea”). Saved in STL format, the resultant data was sent to the CAD-CAM full denture supplier using a specific software package (“Exocad DentalIDB 2.4”) (Figure 3A). The virtual design of the mandibular permanent

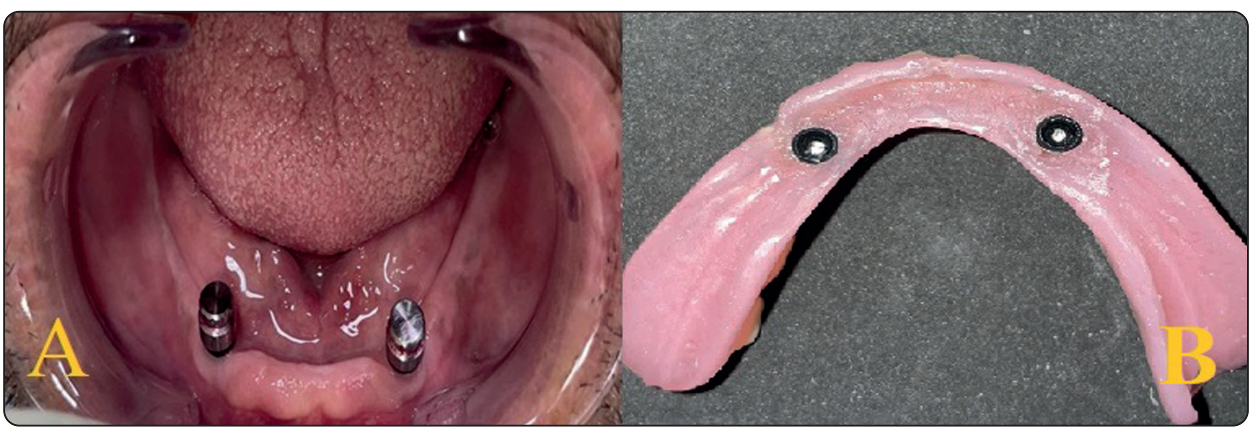


Fig. (2) Direct functional pickup was done intra-orally in conventional overdenture group denture base, including the venting features and cavity for attachment housing was done (Figure 3B). Following manufacturer recommendations, the denture base was then made from prepolymerized CAD-CAM PMMA acrylic plates (98 mm diameter × 25 mm thick) using a milling machine ("ED5X, Emar, Egypt"). The milled base was fitted on the mandibular cast, record block was constructed, then maxillary and mandibular models were mounted on semi-adjustable articulator by the aid of facebow and intermaxillary records. Artificial teeth were set using the same technique as conventional group then intraoral trial denture was done. Flasking was done then teeth were attached to milled base by the aid of self-cure acrylic resin.

Extra-oral pick-up of attachment:

The metal housings were cemented extra orally into their fitting surface cavities of the milled denture base surface using acrylic resin guided by occlusion on semi adjustable articulator. After removing any excess material, the base was finished and polished (Figure 4B). To fix any misalignments in the occlusal plane, the dentures were remounted and checked for accurate contact in both the centric and eccentric planes. Complete modifications were performed intraorally. The retentive nylon inserts were used to replace the lab inserts, and the overdenture was then sent out.

All the patients were educated on the correct methods for inserting and removing the overdenture, home care, and strict oral hygiene practices, along with scheduled follow-up evaluations.

Evaluation

Radiographic evaluation:

Radiography was used to evaluate the peri-implant bone height immediately after overdenture placement, six and twelve months later. Using paralleling technique and a film holder (X-Ray Film Holding Set, Alwings Medical Instrument Company, Shanghai, China), intraoral radiographs were obtained. Standard intraoral radiographs of the implants were obtained using a modified plastic film holder. This change, as defined by Abdel-Khalek et al. [8] "created consistent intraoral imaging by maintaining a constant distance between the X-ray cone and the implant as well as a consistent distance between the implant and the film. Using homogeneous digital films and the identical X-ray equipment" ("ORIX70s, Ardet Srl, Milano, Italy"), "all radiographs were acquired with settings of 70 kVp, 8 mA, 0.144 kW, and an exposure length of 0.25 second"s. Marking reference points and lines using "SCANORA Lite software version 3.2.6" ("PaloDEx Group, Finland") fixed magnification problems. Contrasting the implant dimensions in radiographic images with their actual measurements helped one to find the differences. To get the precise peri-implant bone height, one calculated the ratio of the real fixture size to its radiographic representation.

Walter et al. and Heckmann et al. [9] described vertical peri-implant bone height measurements as utilized to assess the degree of bone resorption. Measuring the distance from the fixture's shoulder (point A) to the highest point of bone-to---implant contact (point B) included the assessment. Vertical bone height was determined and vertical bone loss was computed using a millimeter AB line measurement. (Figure 5A) shows the AB line measurement acquired during insertion against those recorded six and twelve months postoperatively.

Soft tissue outcomes

"Health of soft tissue was evaluated using probing depth (PD). [10-13] "Using a pressure-sensitive plastic probe" ("KerrHawe Clickprobe, Switzerland") that started at a specified location on the abutment neck and continued until it clicked, the millimeters of probing depth were measured. Assessment was done at the "midpoint of four surfaces (buccal, lingual, mesial, and distal) at 0 (base line), 6, and 12-month follow-up visits". (Figure 5B). [12, 13]

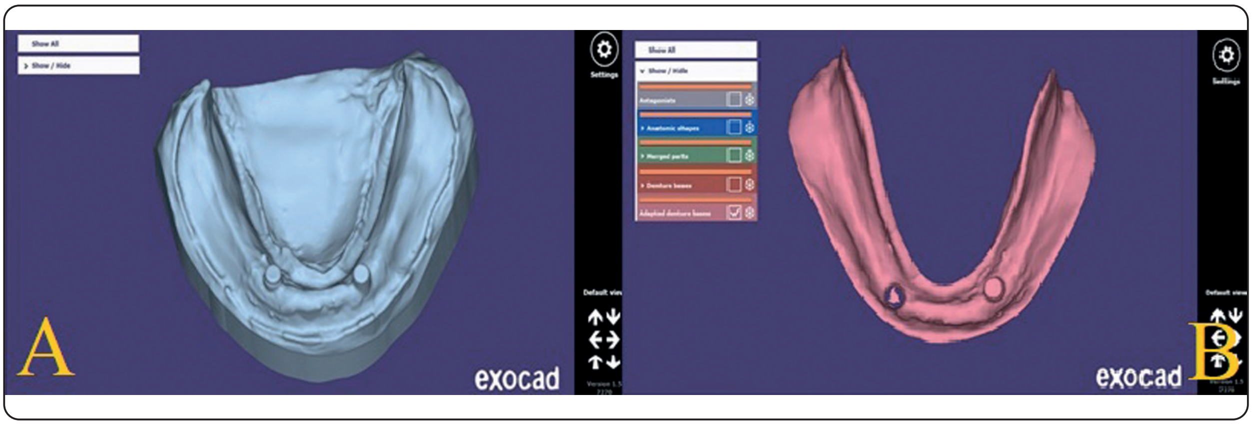


Fig. (3) Master cast was scanned and milled denture base was designed on the software

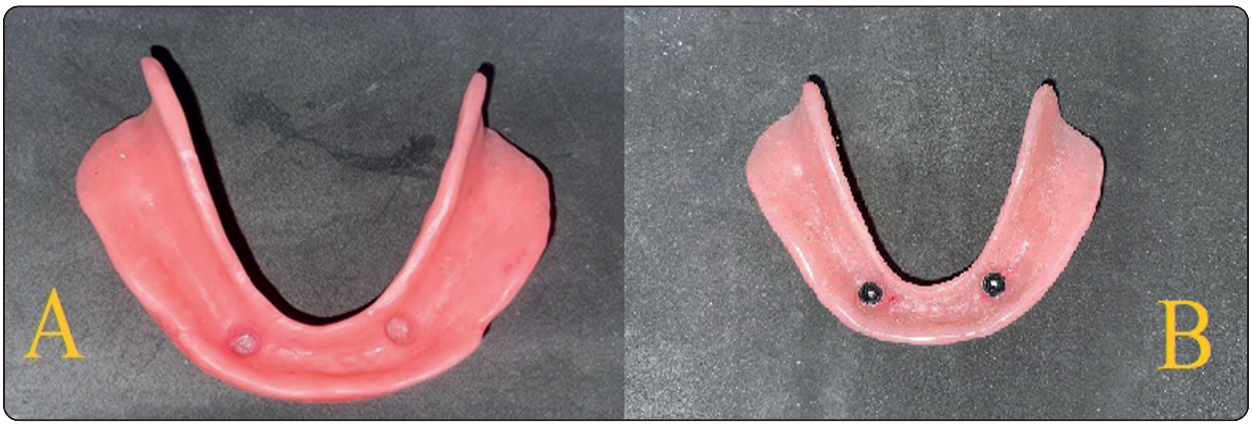


Fig. (4) Pick-up of the metal housing done extra-orally in the digitally designed space in milled base

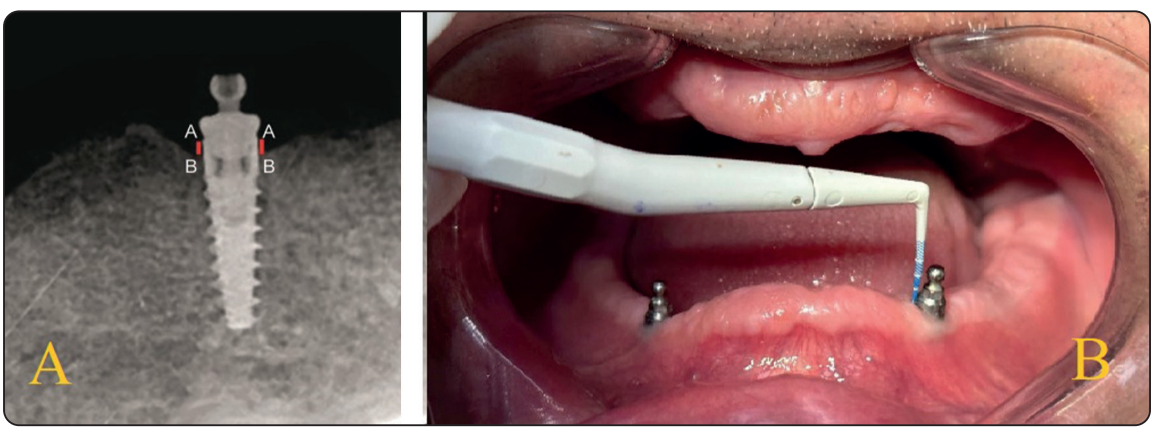


Fig. (5) Evaluation of peri-implant bone loss and probing depth

STATISTICAL ANALYSIS

The data was examined with the help of Windows version 24 of the "Statistical Package for the Social Sciences (SPSS)" application. The first step was to use the Shapiro test to ensure that the data was normal. For data that was regularly distributed, continuous variables were shown as mean ± standard deviation. Independent t-tests were used to compare the two groups, whereas repeated-measures ANOVA tests were employed to examine one group at various follow-up intervals. Continuous data was correlated using Pearson's correlation. When the p-value was less than or equal to 0.05, the findings were deemed significant for all of the aforementioned statistical tests. The significance of the findings is proportional to the size of the p-value.

RESULTS

Table (1) showed that regarding peri-implant crestal bone resorption, there was insignificant difference between groups at different evaluation periods P=0.843 at T0-T6, P= 0.856 at T6-T12 and P= 0.916 at T0-T12. However with advance with time there was significant difference in conventional group from T0-T12 P=0.001, from T6-T12 P≤0.001, in milled group there was significant difference with advance of time T0-T12 P≤0.001, from T6-T12 P=0.001

Table (2) showed that regarding probing depth, there was insignificant difference between groups at different evaluation periods, P=0.615 at T0, P= 0.426 at T6 and P=0.881 at T12. However with advance of time there was significant difference for both groups P<0.001

TABLE (1) Vertical bone height change among Conventional and Milled groups

Vertical bone height change	Conventional group (no=10)	Milled group (no=10)	Test of significance	p value
T0-T6	0.593^{A}± 0.11	0.601 ^{A} ± 0.13	t= 0.200	0.843
T6-T12	0.543 ^{A} ± 0.13	0.551 ^{A}0.11±	t= 0.183	0.856
T0-T12	1.1^{B}± 0.51	1.15 ^{B}0.56±	t= 0.106	0.916
Repeated ANOVA test	F=22.29 P≤0.001*	F=19.16 P≤0.001*	-	-

t: Independent t test, F: Repeated ANOVA test, *significant p≤0.05

TABLE (2) Probing depth among Conventional and Milled groups

Probing depth	Conventional group (no=10)	Milled group (no=10)	Test of significance	p value
T0	1.60 ^{A} ± 0.11	1.58 ^{A} ± 0.11	t= 0.509	0.615
T6	1.90 ^{A} ± 0.11	1.87 ^{A} ± 0.07	t= 0.807	0.426
T12	2.29 ^{A} ± 0.11	2.28 ^{A} ± 0.13	t= 0.151	0.881
Repeated ANOVA test	F=259.7 P≤0.001*	F=204.6 P≤0.001*	-	-

t: Independent t test, F: Repeated ANOVA test, *significant p≤0.05

DISCUSSION

Over the first year, the results of the research showed that assessments of vertical bone loss (VBL) surrounding the implants in both groups maintained within clinically reasonable limits. These findings fit up with the accepted standards for dental implant success defined by Albrektsson et al. [14] which hold that marginal VBL shouldn't be more than 1.5 mm in the first year and that later yearly bone loss should be under 0.2 mm. In the first year after loading, Elsyad and Shoukouki [15] recorded an average marginal bone loss of 1.2 mm; noticed a range of 0.9–1.6 mm with a mean of 1.2 mm during the first year subsequent to implant loading. The two groups showed no statistically significant variation in VBL. This may be attributed to the type of attachment used in both groups. Yoda et al., [16] who argued that the attachment type in implant-supported overdentures is crucial in distributing stresses between implants and the residual ridge, further support the same load-sharing process between implants and residual ridges enabled by uniform attachment types as explained here. Moreover, our results agree with Turker and Buyukkaplan [17] who suggested that different angulations and attachments designed for rotational movement reduce stress on the abutments, implants, and bone.

Additionally, there's a slight increase in VBL observed in the milled overdenture with digital indirect pickup compared to the conventional overdenture with direct pickup. This difference can be due to the direct pickup technique. Since the attachments are picked up directly in the patient's mouth, errors from impression material shrinkage, stone expansion, or laboratory processing are avoided. Direct pickup ensures that the overdenture fits precisely over the attachments, reducing stress on implants. [18]Directly picking up the attachments inside the patient's mouth ensures they are properly seated, reducing the risk of misalignment that can occur with the indirect method. The attachments are picked up under functional conditions, reducing the need for occlusal adjustments or relining later.

Also as attachments are incorporated while the denture is in the mouth, the vertical dimension of occlusion (VDO) remains stable. [19] Patients can leave with a fully functional overdenture in the same appointment, unlike the indirect method, which requires multiple visits. The direct method eliminates the need for multiple try-ins and adjustments, making it more comfortable with minimum stresses on implants and peri-implant alveolar bone. [18]

On the other hand, results showed that peri-implant alveolar bone resorption was kept to normal range in case of digital indirect incorporation of attachment in milled overdentures as milled overdentures offer several advantages over conventional overdentures in terms of precision, fit, durability, and function. Milled overdentures are fabricated using computer-aided design and manufacturing (CAD/CAM), ensuring a highly precise fit compared to conventional acrylic processing, which may introduce human errors. [20] Conventional overdentures often undergo shrinkage or distortion during processing, while milled overdentures are made from pre polymerized blocks, minimizing dimensional changes. Milled overdentures are typically fabricated from highly dense, pre-polymerized PMMA (polymethyl methacrylate), providing better distribution of occlusal forces to underlying structures than conventionally processed dentures. [21, 22] Conventional acrylic dentures may have microvoids that harbor bacteria that may adversely affects the peri-implant soft tissue and underlying alveolar bone.

Also milled overdentures have a highly polished surface with fewer micropores, reducing plaque and bacterial accumulation, improving oral hygiene and peri-implant tissue health.[23] The lower porosity minimizes the risk of fungal infections (e.g., denture stomatitis), which is a common problem with conventional dentures. The adaptation to the implant abutments and soft tissue is more accurate, leading to better retention and stability compared to conventionally processed dentures. [24]

Regarding the probing depth in both groups, there was no statistically significant difference. The probing depth was in normal range this can be attributed to removable overdenture. Implant retained overdentures (IRODs) are removable, allowing for direct cleaning of the implant abutments, soft tissues, and denture base more effectively. [25] Since overdentures can be removed for thorough cleaning, there is a lower risk of plaque-induced inflammation and peri-implant diseases. Due to reduced bacterial accumulation, there is often less marginal bone loss around implants compared to fixed prostheses, where poor hygiene can lead to progressive bone resorption. Because IRODs allow better hygiene access, peri-implant soft tissues tend to remain healthier with less redness, swelling, or bleeding on probing (BOP) compared to fixed restorations. [26]

IRODs allow for some movement, which helps distribute occlusal forces evenly to different implants which transfer these forces to the bone. The soft tissues around implant overdentures often show better adaptation and fewer inflammatory changes due to improved cleaning and reduced plaque accumulation. Overdentures allow for easier interventions, including professional cleaning, abutment adjustments, or replacing components. [27]

Despite the strength of the study, there are some limitations to be discussed. First, the small sample size (n=30), which may limit the generalizability of the findings to larger populations this is because of resource constraints. Second, the short evaluation period this may not give data about long term effects. However, it still allowed for preliminary conclusion and give deep insight about the high precision of digital indirect pick-up and direct functional pick-up for incorporation of overdenture attachment and their comparable effects on vertical bone loss and probing depth around implants. Further studies are needed including larger sample size, longer evaluation period and evaluating other physical characteristics of 3D-milled overdentures compared to conventional heat cured ones.

CONCLUSION

It was concluded that indirect pick-up carried-out by digital technique for incorporation of implant overdenture attachment in milled denture is comparable to direct functional pick-up in conventionally constructed overdenture regarding peri-implant probing depth and alveolar bone loss.

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